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# FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION
R2-92-05

## TRENDS IN OVERWINTERING EGG POPULATIONS OF A PINE SAWFLY, *NEODIPRION AUTUMNALIS*, ON PONDEROSA PINE SAMPLED IN JANUARY AND DECEMBER 1991 NEAR FT. MEADE IN SOUTH DAKOTA

May 1992

United States Department of Agriculture
Forest Service
Forest Pest Management
Denver, Colorado

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ABSTRACT

In 1990 and 1991, a number of outbreaks of the pine sawfly, Neodiprion autumnalis, were reported in western South Dakota and eastern Wyoming. Near Ft. Meade in South Dakota, defoliation in 1990 was heavy at the center of the infestation and decreased to light defoliation at a distance of 1 mile from the center. Defoliation at the same location in 1991 appeared to range from heavy to moderate.

Three sites near Ft. Meade that were sampled in January 1991 were resurveyed in December 1991 to assess changes in overwintering egg populations and degree of defoliation and to determine the potential for defoliation in 1992. Egg densities were at least 2-4 times lower in the December 1991 samples. Sample branches (about 2 ft. long) collected at 20 ft. above ground averaged between 0.4 and 1.0 infested shoots per branch, 1-6 infested needles per branch, and 28-85 eggs per branch. Egg densities were highest 1/4 mile from the center of the infestation and lowest 1 mile out. Average numbers of eggs per needle were similar for the two sample periods. Compared to January 1991 samples, branches had a far lower mean number of sawfly colonies (0.5-1.1) but averaged a similar number of eggs per colony (61-80). Eggs were laid in all ages of foliage, but were mainly laid in 1991 foliage. This preferential use of current year needles was more pronounced than for January 1991 samples. Relative to January 1991 samples, about 30% more foliage remains on trees at the infestation center, while 40% and 35% less foliage is present on trees at sites 1/4 and 1 mile distant. About 8-11 needles per sawfly egg are available for consumption in 1992 near the center of the infestation, whereas 35 needles are available per sawfly egg at 1 mile out.

Defoliation near Ft. Meade in 1992 is expected to be moderate to light. Defoliation is expected to be lighter near the perimeter of the infestation and the population decline is expected to continue into 1993. Tree mortality is not likely to result directly from the defoliation; however, drought stress and subsequent infestation by Ips bark beetles may cause small losses. No action is needed to reduce sawfly populations on government lands because trees are expected to recover following collapse of the sawfly population. Insecticide applications can be considered for other locations where protection of aesthetics is of high concern, such as yard trees located on private property.

## INTRODUCTION

In late July and early August 1990, many private landowners in western South Dakota and eastern Wyoming contacted various county, state, and federal offices concerning heavy defoliation of ponderosa pine (Pinus ponderosa Dougl. ex Laws.) by a pine sawfly, Neodiprion autumnalis (Smith) (Hymenoptera: Diprionidae). In South Dakota, outbreak areas were located between Spearfish and Belle Fourche, near Ft. Meade, and within Wind Cave National Park and adjacent private property. In 1991, outbreak pockets also were reported from Sturgis to Rapid City, at Hot Springs, and in Custer State Park in South Dakota. Affected

sites tended to be areas of widely-spaced trees with poor growth on dry sites with poor soils. The entire region had been experiencing a drought since 1988. In response to this situation, Forest Health Management personnel from the Rapid City Service Center prepared a biological evaluation (Pasek 1991) that summarized the biology of N. autumnalis (Dahlsten 1961; Smith & Wagner 1986), estimated the 1990-1991 overwintering egg population and degree of 1990 defoliation from field samples, and presented management recommendations based on levels of defoliation predicted for 1991.

In 1991, heavy to severe defoliation reoccurred at the center of the infestation near Ft. Meade, while peripheral areas experienced moderate defoliation, as predicted (Pasek 1991). Significant rainfall in the spring of 1991 likely reduced the stress on the pines caused by drought and defoliation.

The purposes of this evaluation were to estimate 1991-1992 overwintering sawfly populations near Ft. Meade, determine whether control measures may be needed in 1992, and obtain additional biological information pertaining to N. autumnalis eggs that could be useful for assessing populations and potential damage levels for future years and infestations.

## METHODS

Branch samples were collected on 9, 12, and 13 December, 1991, from ponderosa pines at three sites near Ft. Meade, SD, on federal land managed by the Bureau of Land Management. Site 1 was located immediately west of the Ft. Meade Cemetery, site 2 was in a draw approximately 1/4 mile southeast of the cemetery, and site 3 was on a ridge about 1 mile south of the cemetery. These are the same sample sites that were used in January 1991 (Pasek 1991). From each sample tree, four branches approximately 2 ft. in length were removed from a height of about 20 ft. (approximately mid-crown level) using a pole-pruner. Each of the four branches was collected from a different side of the tree. Ten trees were sampled per site; therefore, forty branches were collected from each site.

Sample branches were examined to determine numbers of needles by year of growth (1991, 1990, and 1989 or older), number of needles with sawfly eggs by year of growth, total number of shoots and number of shoots with sawfly eggs, number of sawfly eggs per needle and colony and branch, and number of egg colonies per branch. Needles were counted if at least 2 in. remained. A shoot was defined by the presence of a bud and all the needles between it and a branch fork or node. Each brown spot along the edge of infested needles was counted as one sawfly egg except the first brown spot proximal to the needle base. An egg is not deposited in this initial slit, which is thought to function to sever the needle's resin canal. A sawfly colony included a group of needles in close proximity to each other (separated by not more than a few needles) that contained sawfly

eggs. Maximum and minimum values and means were determined for each variable at each site. Summary statistics were calculated from combinations of variables as appropriate. Percent change was calculated for certain variables in relation to data from the January 1991 samples. Comparisons were made based on age of foliage rather than calendar year of growth, (e.g., change in one-year-old needles was made by comparing 1990 foliage in the January 1991 samples to 1991 foliage in the December 1991 samples).

## RESULTS AND DISCUSSION

Pines at all three sites displayed the effects of two years of defoliation; remaining foliage was concentrated toward the branch tips, giving the trees a sparse, tufted appearance. Branches at site 3, where defoliation was light to moderate, had approximately 35% to 37% more needles as compared with the branches at sites 1 and 2, where defoliation was moderate to severe (Table 1). The number of remaining needles per shoot in December 1991 compared with January 1991, increased at site 1 by 30%, decreased at site 2 by 40%, and decreased at site 3 by 35%. Because the numbers of shoots per branch or per inch of branch were similar between sample dates and sites, the differences in needles per shoot represent actual changes in the amount of foliage present on the trees.

A higher proportion of current-year foliage remained on the December 1991 branches, because of greater consumption in 1991 of the older needles and increases in current-year foliage. At site 1, 92% of remaining foliage was 1991 growth and 75% and 80% of branches were completely stripped of 1990 and 1989 & older foliage, respectively (Table 1). At site 2, 71% of remaining foliage was 1991 growth and the same percentages of branches as site 1 were stripped of older foliage. At site 3, the majority (58%) of foliage also was new growth, although older age classes were better represented. Despite being the least defoliated, site 3 had 15% of branches devoid of 1990 foliage and 28% of branches lacking 1989 & older foliage. Generally, four age classes of needles are equally distributed on undefoliated ponderosa pines. The foliage age profile at site 3 in the December 1991 samples resembled that of site 1 in the January 1991 samples, which was most heavily defoliated in 1990 (Pasek 1991).

Abundance of pine sawfly eggs was greatest at site 2, intermediate at site 1, and least at site 3 (Table 2). The number of infested shoots per branch averaged between 0.4 and 1 and ranged to a high of 3. This represents approximately 3-7% of sample shoots being infested with sawfly eggs. Colony density declined from the 6-9 shoots per colony present in January 1991 to 14-35 shoots per colony in December 1991 (Pasek 1991). Egg populations declined substantially (about 40% or greater for most variables) at all three sites from January 1991 to December 1991, and generally indicated a two-fold to four-fold reduction in numbers.

**Table 1.** Needle abundance for ponderosa pine branch samples collected at 20 ft. in December 1991 near Ft. Meade, South Dakota (N per site = 40 branches, 4 each taken from 10 trees; SD = standard deviation of samples; % Change is relative to January 1991 samples)

| BRANCH VARIABLE | SITE 1 | SITE 2 | SITE 3 |
|---|---|---|---|
| Length (in.) | | | |
| Minimum | 20 | 22 | 15 |
| Maximum | 43 | 45 | 39 |
| Mean ± SD | 30.0 ± 5.9 | 30.2 ± 5.3 | 26.5 ± 4.4 |
| % Change | 13% | 25% | 16% |
| All needles | | | |
| Minimum | 210 | 232 | 262 |
| Maximum | 1654 | 2356 | 2751 |
| Mean ± SD | 714.3 ± 298.9 | 708.5 ± 439.7 | 968.0 ± 562.7 |
| % Change | 30% | -40% | -35% |
| 1991 needles | | | |
| Minimum | 210 | 217 | 155 |
| Maximum | 1279 | 1319 | 2751 |
| Mean + SD | 659.3 ± 246.6 | 505.8 ± 227.1 | 564.9 ± 412.6 |
| % Change | 93% | 20% | 30% |
| 1990 needles | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 399 | 457 | 600 |
| Mean ± SD | 22.3 ± 77.8 | 48.2 ± 107.2 | 158.8 ± 169.6 |
| % Change | -81% | -85% | -56% |
| 1989 & older needles | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 761 | 1479 | 911 |
| Mean ± SD | 32.7 ± 139.4 | 154.5 ± 347.0 | 244.3 ± 285.6 |
| % Change | -64% | -64% | -65% |
| Shoots | | | |
| Minimum | 4 | 4 | 5 |
| Maximum | 72 | 50 | 39 |
| Mean ± SD | 17.5 ± 12.2 | 14.8 ± 8.4 | 15.9 ± 8.2 |
| % Change | 6% | 2% | -20% |
| % branches without needles | | | |
| 1991 | 0 | 0 | 0 |
| 1990 | 75 | 75 | 15 |
| 1989 & older | 80 | 80 | 28 |
| Overall | 0 | 0 | 0 |
| % of all needles by age | | | |
| 1991 | 92% | 71% | 58% |
| 1990 | 3% | 7% | 16% |
| 1989 & older | 5% | 22% | 25% |

**Table 2.** Pine sawfly egg abundance for ponderosa pine branch samples collected at 20 ft. in December 1991 near Ft. Meade, South Dakota (N per site = 40 branches, 4 each taken from 10 trees; SD = standard deviation; % Change is relative to January 1991 samples)

| BRANCH VARIABLE | SITE 1 | SITE 2 | SITE 3 |
|---|---|---|---|
| Shoots with eggs | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 3 | 3 | 2 |
| Mean ± SD | 0.8 ± 1.0 | 1.0 ± 1.0 | 0.4 ± 0.6 |
| % Change | -60% | -29% | -75% |
| % shoots with eggs | | | |
| Over all samples | 5% | 7% | 3% |
| Branch mean ± SD | 7% ± 9% | 7% ± 7% | 3% ± 5% |
| % Change | -56% | -41% | -67% |
| Needles with eggs | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 18 | 30 | 10 |
| Mean ± SD | 4.3 ± 5.5 | 6.2 ± 7.7 | 1.4 ± 2.7 |
| % Change | -75% | -38% | -86% |
| Eggs over all branches | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 323 | 341 | 175 |
| Mean ± SD | 67.7 ± 90.8 | 84.9 ± 98.4 | 27.5 ± 53.3 |
| % Change | -73% | -42% | -80% |
| --Eggs on 1991 needles | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 323 | 327 | 175 |
| Mean ± SD | 67.6 ± 90.6 | 81.4 ± 91.3 | 20.4 ± 50.1 |
| % Change | -67% | 8% | -20% |
| --Eggs on 1990 needles | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 3 | 140 | 91 |
| Mean ± SD | 0.1 ± 0.5 | 3.5 ± 22.14 | 3.5 ± 15.9 |
| % Change | -100% | -93% | -95% |
| --Eggs on 1989 & older needles | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 0 | 0 | 105 |
| Mean ± SD | 0 | 0 | 3.5 ± 16.7 |
| % Change | -100% | -100% | -90% |
| Sawfly colonies | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 4 | 5 | 2 |
| Mean ± SD | 1.0 ± 1.2 | 1.1 ± 1.2 | 0.5 ± 0.7 |
| % Change | -63% | -50% | -78% |

Egg deposition characteristics were similar in January and December 1991 samples. These characteristics also were like those reported for the Willits and Mt. Shasta sawfly populations in California by Stark and Dahlsten (1965), reinforcing the assertion that these populations are predominantly N. autumnalis. A small percentage of Neodiprion gillettei (Rohwer) also may be present in South Dakota, since a few larvae with black head capsules were detected during 1991 (personal communication, Rich Dorset, SD Div. Forestry).

The number of eggs laid per colony (Table 3) was consistent with previous reports and probably represents the full compliment of eggs of a given female, ranging from 60-80 (Dahlsten 1961, 1966; Pasek 1991). The fecundity of individual female sawflies appears to have been unaffected by population pressure in 1991.

The mean number of eggs laid per needle in fall 1991 generally ranged from 12-20 (Table 4), much like the 11-15 figure from fall 1990 (Pasek 1991) and the 17-20 reported in California (Dahlsten 1966). Most eggs were deposited along one edge of a needle similar to observations found in January 1991 samples (Pasek 1991); only one instance of eggs being laid on both sides of a needle was noted in the December 1991 samples.

Stark & Dahlsten (1965) reported a tendency for the mean number of eggs per needle to decrease with increasing needle age at the Mt. Shasta site, that was not statistically significant. Numbers of eggs per needle were relatively constant for different ages of foliage at Ft. Meade in January 1991 samples, except for older foliage (1989 & older) in lower crown branches where sample sizes were small (Pasek 1991). Again in the December 1991 samples, numbers of eggs per needle were similar for different ages of foliage at sites 1 and 2 (Table 4). At site 3, however, older foliage had fewer eggs per needle. The difference between eggs per needle on 1991 and 1989 and older foliage was statistically significant among the three possible contrasts using the t-test in conjunction with Bonferroni's inequality ($p = 0.05$ overall).

The reported tendency to preferentially lay eggs in the current-year foliage (Stark & Dahlsten 1965), observed at sites 1 and 2 in January 1991 samples (Pasek 1991), was clearly evident in December 1991 samples (Table 3). At site 1, where most (92%) of foliage was 1991 growth, nearly all (99%) sawfly eggs were necessarily laid in 1991 foliage. At site 2, where 71% of all foliage was 1991 growth, nearly all (96%) eggs were laid in 1991 foliage. At site 3, where 58% of all foliage was 1991 growth and the older age classes were better represented, sawflies still laid 74% of all eggs in 1991 foliage.

**Table 3.** Pine sawfly population abundance on ponderosa pine branch samples collected at 20 ft. in December 1991 near Ft. Meade, South Dakota (N per site = 40 branches, 4 each taken from 10 trees; SD = standard deviation of samples; % Change is relative to January 1991 samples)

| VARIABLE | SITE 1 | SITE 2 | SITE 3 |
|---|---|---|---|
| % branches with eggs: | | | |
| Overall | 53% | 63% | 33% |
| on 1991 needles | 53% | 63% | 20% |
| on 1990 needles | 3% | 3% | 8% |
| on 1989 & older needles | 0% | 0% | 13% |
| Needles per colony | | | |
| Minimum | 1 | 1.5 | 1 |
| Maximum | 11 | 10.0 | 7 |
| Mean ± SD | 4.8 ± 2.3 | 5.5 ± 2.1 | 3.0 ± 2.0 |
| n (infested branches) | 21 | 25 | 13 |
| Eggs per colony | | | |
| Minimum | 11 | 3 | 3 |
| Maximum | 181 | 143 | 171 |
| Mean + SD | 71.8 ± 37.6 | 79.5 ± 31.0 | 61.0 ± 49.5 |
| n (infested branches) | 21 | 25 | 13 |
| Shoots per colony overall | 18.4 | 13.8 | 35.3 |
| % Change | 197% | 109% | 27% |
| Needles per egg | | | |
| Minimum | 2.9 | 1.1 | 4.8 |
| Maximum | 141.3 | 123.0 | 410.5 |
| Mean ± SD | 17.2 ± 32.4 | 11.9 ± 24.8 | 77.2 ± 136.0 |
| n (infested branches) | 21 | 25 | 13 |
| % Change of Mean | 142% | 45% | 179% |
| Needles per egg overall | 10.6 | 8.3 | 35.3 |
| % Change | 381% | 4% | 227% |
| Eggs per needle for all branches | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 0.50 | 0.92 | 0.21 |
| Mean ± SD | 0.09 ± 0.12 | 0.15 ± 0.19 | 0.02 ± 0.05 |
| % of all eggs laid on | | | |
| 1991 needles | 99% | 96% | 74% |
| 1990 needles | 1% | 4% | 13% |
| 1989 & older needles | 0% | 0% | 13% |
| % of all needles by age | | | |
| 1991 | 92% | 71% | 58% |
| 1990 | 3% | 7% | 16% |
| 1989 & older | 5% | 22% | 25% |

**Table 4.** Pine sawfly egg abundance for individual needles on ponderosa pine branch samples collected at 20 ft. in December 1991 near Ft. Meade, South Dakota (40 branches per site, 4 each taken from 10 trees; SD = standard deviation of samples)

| NEEDLE VARIABLE | SITE 1 | SITE 2 | SITE 3 |
|---|---|---|---|
| Eggs per individual infested needle: | | | |
| --on all needles | | | |
| Minimum | 2 | 1 | 1 |
| Maximum | 44 | 29 | 41 |
| Mean ± SD | 15.7 ± 8.1 | 13.8 ± 7.3 | 19.6 ± 11.0 |
| n (needles w/ eggs) | 173 | 246 | 56 |
| --on 1991 needles | | | |
| Minimum | 2 | 1 | 3 |
| Maximum | 38 | 29 | 41 |
| Mean ± SD | 15.8 ± 8.0 | 13.9 ± 7.2 | 22.7 ± 11.0 |
| n (needles w/ eggs) | 171 | 234 | 36 |
| --on 1990 needles | | | |
| Minimum | 1 | 3 | 1 |
| Maximum | 2 | 24 | 30 |
| Mean ± SD | 1.5 ± 0.7 | 11.7 ± 7.9 | 15.7 ± 10.2 |
| n (needles w/ eggs) | 2 | 12 | 9 |
| --on 1989 & older needles | | | |
| Minimum | 0 | 0 | 1 |
| Maximum | 0 | 0 | 22 |
| Mean ± SD | 0 | 0 | 12.7 ± 7.0 |
| n (needles w/ eggs) | 0 | 0 | 11 |

Egg densities in relation to available foliage were highest at site 2 and lowest at site 3 (Table 3). At site 1, there were about 11 needles available per sawfly egg, an increase from the 2-3 available in January 1991 samples (Pasek 1991). At site 2, there were 8 needles available for every egg, unchanged from the prior samples. At site 3, there were 35 needles available per sawfly egg, three times more than were available in January 1991. Since these values were calculated from overall needle and egg counts at each site, they do not reflect variations in distribution from branch to branch or tree to tree. Means that were calculated using only branches that contained eggs ranged from a low of 12 needles per egg per infested branch at site 2 to a high of 77 needles per egg per infested branch at site 3 (Table 3). The same relative trend in egg density by site was evident from both measures of available foliage. Starvation of sawfly larvae in 1992 is possible at sites 1 and 2, but is unlikely at site 3. No figures have been documented as to how many needles an average larva consumes during the course of its development, but the 8-11 needles per egg available at sites 1 and 2 may be insufficient for some sawfly

larvae, known to be ravenous feeders. A slightly higher number of needles may actually be available per feeding larva because of some mortality of eggs and first-instar larvae. Larvae that run out of food on a given branch or tree exhibit wandering behavior in search of food, and can readily be seen crawling up and down tree trunks and across the ground (Dahlsten 1961). This behavior may occur in the 1992 population at Ft. Meade, particularly for later instars.

In the absence of artificial control measures, defoliation can be expected to be moderate at the center of the infestation (site 1), moderate to heavy at 1/4 mile from the population center (site 2), and light at 1 mile from the population center (site 3). Although no areas beyond 1 mile were sampled, the infestation may include a somewhat larger area in 1992 relative to 1991. No tree mortality directly resulting from this pine sawfly species (or closely related species) has been reported even after complete defoliation of older needles (Dahlsten 1966), and is not expected to result from the current epidemic. Apparently the presence of current-year needles, which are least preferred and are partially consumed only when older foliage is lacking, is sufficient to sustain pines under normal circumstances.

The sawfly population at Ft. Meade is beginning to decline following two years of heavy defoliation. Pine sawfly populations typically collapse following one or two years of epidemic levels as a result of mortality from a combination of parasites, predators, disease, starvation, and other natural causes, such as adverse weather conditions. Because of the high reproductive potential of females, mortality of 95% of the sawfly population (from egg to adult) is necessary just to maintain population levels (Dahlsten 1967). Small increases in mortality above 95% contribute to rapid decline of an infestation. The high larval population densities at sites 1 and 2 in 1991 may have contributed to disease spread and starvation. Poor survival of pupae caused by disease, starvation effects, or parasitism likely contributed to the rapid decline in egg numbers observed in December 1991 samples. The population at Ft. Meade can be expected to continue to collapse in 1993, with defoliation levels likely to be in the light to negligible range at all sites. At other infested locations in South Dakota, a similar scenario is likely for sites that have been heavily to severely defoliated in 1990 and 1991. For sites that have been heavily defoliated only one year in 1991, heavy to severe defoliation is likely for 1992 followed by a rapid decline in sawfly population density in subsequent years.

## ALTERNATIVES

Alternative 1: Insecticide Application - Foliage can be sprayed aerially or using ground equipment with an appropriately registered chemical insecticide, such as carbaryl (Sevin) or malathion. Application should be timed to coincide with the presence of less than full-grown larvae (2nd to 4th instar), which are likely to occur in June to early July in South Dakota depending upon weather conditions.

Alternative 2: Biological Control - Parasitic insects can be released to augment the natural enemy complex or to temporarily inundate the sawfly population. Availability of parasitic insects for release can be problematic and the short-term efficacy of such releases is unknown.

Alternative 3: Do Nothing - Accept defoliation as a natural phenomenon. Pine sawfly populations typically decline rapidly within a couple years following the initiation of an outbreak and most trees recover.

## RECOMMENDATION

Because the current sawfly infestation at Ft. Meade is declining, the no action alternative is recommended. This recommendation likely applies to all publically-owned lands affected by pine sawflies in the Black Hills area of South Dakota. Private land owners who are concerned about the appearance of their trees, particularly those located in yards, may want to consider applying insecticides to reduce defoliation.

For most non-timber producing sites, the cost of applying insecticides can not be justified in relation to the resource values (wildlife, recreation, aesthetics, etc.). Also, insecticide application might not result in resource enhancement given the short-term nature of sawfly epidemics and the potential adverse effects of insecticides on sawfly natural enemies. The Do Nothing alternative is likely best for most of these sites. Parasitic insects could be released if an adequate supply can be produced.

Insecticide application may be considered for high value sites, such as recreation and historical sites, where protection of aesthetic character and shading is important. Insecticide application also may be an appropriate alternative where valuable trees are located in proximity to trees infested by pine engraver beetles (Ips spp.), which preferentially attack and kill weakened trees. Currently, small pockets of tree mortality caused by Ips are scattered throughout the area infested by the pine sawfly; Ips populations have increased in the Black Hills area since 1988 in response to a continuing drought. However, some additional tree mortality is not expected to

significantly impact resource values, because the primary values in the Ft. Meade area are wildlife habitat and recreational opportunities.

## ACKNOWLEDGMENT

Appreciation is extended to Walter Green (temporary range technician, Pactola Ranger District), who diligently counted shoots, needles, and sawfly eggs on collected branch samples. Nancy Campbell (Northern Region, Forest Pest Management) assisted with pole-pruning.

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